MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2017/2018

EME3206 – CONTROL ENGINEERING

(ME)

03 MARCH 2018
2.30PM - 4.30PM
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 6 pages including cover page with 4 Questions only.
2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.
4. Table of Transform pairs has been included in Appendix.

Question 1

(a) Figure Q1 (a) shows a mass spring damper system in which the input motion $x_i(t)$ results in mass output motion $x_o(t)$. Assuming the contact between the mass m and the ground is frictionless, derive the dynamic model of the system. Obtain Laplace transformations of the model equations, assuming zero-initial-conditions. Draw the block diagram relating the output $X_o(s)$ to the input $X_i(s)$.

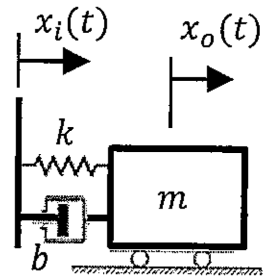

Figure Q1 (a). A mass-spring-damper system

[10 marks]

(b) For the block diagram of a system shown in Figure Q1(b), apply the rules of block diagram manipulation to obtain the closed loop transfer function $\frac{C(s)}{R(s)}$.

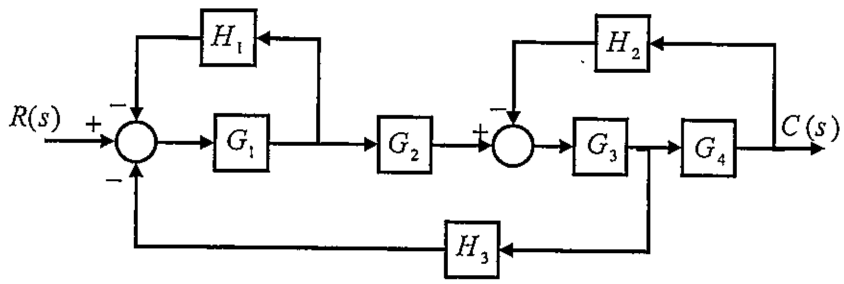

Figure Q1 (b). Block diagram of a system

[15 marks]

Continued...

Question 2

(a) The open loop transfer function of a unity feedback system is

$$G(s) = \frac{9}{s(s+3)}$$

Determine:

(i) Natural frequency ω_n, and damping ratio ξ of the system.

(ii) Given that the sytem is excited with a unit step input, find the time of the first peak t_p, the settling time t_s, and the maximum overshoot M_p.

(iii) Using the found values in (ii), sketch the unit step reponse of the system, $c(t)$.

[4 + 7 + 2 marks]

(b) The open loop transfer function of a unity feedback system is

$$G(s) = \frac{k}{s(s+2)},$$

Calculate :

(i) The error constants for step, ramp and parabolic inputs, k_p, k_v, and k_a.

(ii) The steady state error e_{ss}, for step, ramp and parabolic inputs

[6 + 6 marks]

Continued...

Question 3

(a) The open loop transfer function of a unity feedback control system is given by

$$G(s) = \frac{K}{s(s+4)(s^2+4s+20)}$$

Using Routh-Hurwitz criterion, determine the range of K for stability of the system

[9 marks]

(b) A unity feedback control system has an open loop transfer function

$$G(s) = \frac{K}{s(s+1)(s+2)}$$

Determine the following

(i) Starting points of root loci of the system

(ii) Angle of Asymptotes of root loci and intersection of asymptotes

(iii) Break-away points

(iv) Intersection point with imaginary axis

(v) Sketch the root locus (Use graph sheet)

[3 + 2 + 3 + 4 + 4 marks]

Continued...

Question 4

(a) The open loop transfer function of a feedback control system is given by

$$G(s)H(s) = \frac{5}{s^3 + 3s^2 + 2s}$$

Sketch the Nyquist plot and determine the gain margin using Nyquist criteria.

[15 marks]

(b) Consider a designed mechanical system with state space design model

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & -5 \end{bmatrix} \cdot \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} . u(t)$$

$$y(t) = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Design the state transition matrix of mechanical system

[10 marks]

Continued...

Appendix – Laplace Transform Pairs

f(t)	F(s)
Unit impulse δ (t)	1
Unit step u(t)	$\frac{1}{s}$
t	$\frac{1}{s^2}$
$\frac{t^{n-1}}{(n-1)!}$ (n = 1, 2, 3, …)	$\frac{1}{s^n}$
t^n (n = 1, 2, 3, …)	$\frac{n!}{s^{n+1}}$
e^{-at}	$\frac{1}{s+a}$
te^{-at}	$\frac{1}{(s+a)^2}$
$\sin \omega t$	$\frac{\omega}{s^2+\omega^2}$
$\cos \omega t$	$\frac{s}{s^2+\omega^2}$
$e^{-at}\sin \omega t$	$\frac{\omega}{(s+a)^2+\omega^2}$
$e^{-at}\cos \omega t$	$\frac{s+a}{(s+a)^2+\omega^2}$
$1-\cos \omega t$	$\frac{\omega^2}{s(s^2+\omega^2)}$
$\omega t-\sin \omega t$	$\frac{\omega^3}{s^2(s^2+\omega^2)}$
$\sin \omega t-\omega t\cos \omega t$	$\frac{2\omega^3}{(s^2+\omega^2)^2}$
$\frac{1}{2\omega}t\sin \omega t$	$\frac{s}{(s^2+\omega^2)^2}$
$t\cos \omega t$	$\frac{s^2-\omega^2}{(s^2+\omega^2)^2}$

End of paper